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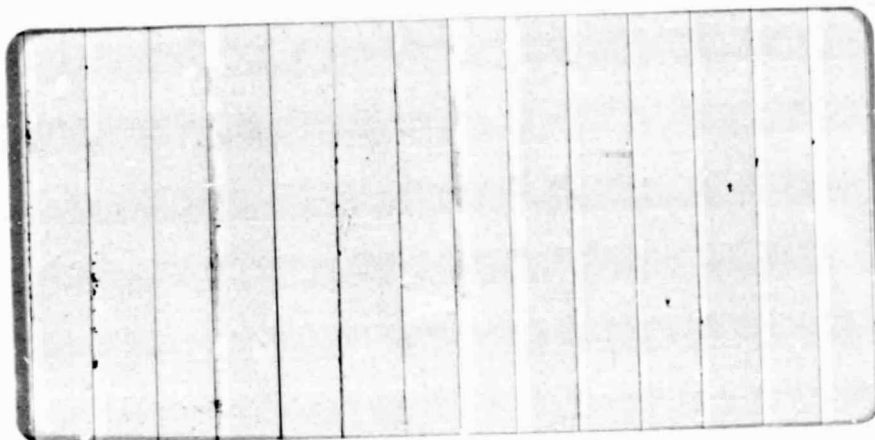
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TEST PACKAGES FOR PARTICLE IMPACT NOISE
DETECTION Final Report, Jul. - Dec. 1977
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AEROSPACE GROUPS
CULVER CITY, CA 90230

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CONTAMINATION CONTROL IN HYBRID MICROELECTRONIC MODULES
(Contract NAS 8-30876)

FINAL REPORT

PREPARATION OF CALIBRATED
TEST PACKAGES FOR PARTICLE
IMPACT NOISE DETECTION
JULY-DECEMBER 1977

Prepared for:

NASA - George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35912

NASA Technical Manager: Mr. S. V. Caruso
Electronics and Control Laboratory

By: Hughes Aircraft Company
Aerospace Groups
Culver City, California 90230

Hughes Program Manager: Mr. F. Z. Keister
Microcircuit Department, Technology Support Division

PREFACE

This final report was prepared by Hughes Aircraft Company, Culver City, California, in fulfillment of Supplemental Agreement Number 7 to Contract Number NAS 8-30876, "Contamination Control in Hybrid Microelectronic Modules." The work was sponsored by the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Alabama with Mr. S. V. Caruso serving as the NASA Technical Manager. The Hughes Program Manager was Mr. F. Z. Keister, Microcircuit Department. This final report covers work conducted from July 1977 through December 1977.

The 165 seeded hybrid packages delivered under this contract were intended for Mr. S. Gaudiano, NASA/Johnson Space Center, Houston, Texas.

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1.0 INTRODUCTION AND SUMMARY

1.1 OBJECTIVE

The objective of this program was to develop methods and procedures for the preparation of PIND test devices which contain loose internal particles whose mass is accurately known. In addition, it was to prepare and deliver 125 sealed and seeded standard hybrid microcircuit test devices and 40 sealed and seeded field test device hybrid packages.

1.2 BACKGROUND

Over the past several years it has been recognized that particulate contamination in the form of loose particles has been responsible for a substantial number of failures in hybrid microcircuits. A recent study at Hughes revealed that loose conductive particles cause about one of every six failures in military hybrid circuits. Most of these failures are due to gold and solder particles resulting from wire bonding, electroplating, and solder sealing of packages. Other companies have experienced similar findings.

Particle Impact Noise Detection (PIND) testing has gained widespread acceptance as a method for detecting these loose particles. One of the problems in PIND testing is the lack of a good means for calibrating various PIND systems. For example, a PIND test by one hybrid vendor may result in a package being rejected while a PIND test of the same package by another vendor could result in acceptance. Part of this could be due to operator training and interpretation, part could be due to the equipment itself (e.g., background noise, gain, sensitivity, etc.), and part could be due to the manner in which the equipment is being used and the methods being employed for freeing trapped particles. At the time this study was undertaken, there was as yet no industry standard for calibrating PIND test systems, nor any good way to check whether there was

any correlation between PIND equipments (or operator subjectivity) at various hybrid manufacturers. The families of standard test devices and field test packages prepared under this program are intended as a standard calibration method for any PIND test system, as well as providing a means for evaluating the effectiveness of vendors who are presently performing PIND testing for government hardware programs.

1.3 SUMMARY

The initial phase of this program involved the selection and characterization of the particles to be used for seeding the hybrid packages. The particles selected were commercially-purchased gold balls in three weights- 0.17 ugm, 0.5 ugm, and 1.0 ugm. The gold balls were manufactured by dropping gold powder into a molten salt bath. Characterization of the particles was done by measuring their diameters optically at 500X magnification.

Five different hybrid package types were selected. These included three sizes of metal butterfly packages - 3.2 x 3.2 mm (1-1/4 x 1-1/4-inch), 2.54 x 2.54 mm (1 x 1-inch), and 1.59 x 1.59 mm (5/8 x 5/8-inch). In addition, there was a 2.54 x 2.54 (1 x 1-inch) ceramic flatpack and a TO-8 header. Each package was carefully seeded with a single gold ball (or a gold wire of equivalent weight), hermetically sealed, leak tested, and finally PIND tested.

The seeded packages were divided into twenty-five groups of five each standard test devices and four groups of ten each field test packages, giving a total of one hundred and sixty-five packages. Each package in each group was marked with an alphanumeric code to identify the size and type of particle which had been used to seed that particle package.

2.0 PROGRAM TASKS

The program consisted of four main tasks:

Task 1. Prepare and characterize particles. This included investigating novel particle manufacturing techniques, evaluating commercially-available particles and investigating methods for accurately characterizing the mass of the particles.

Task 2. This task consisted of fabricating a family of standard test devices containing particles of known mass. This involved preparing twenty-five sets of five each seeded hybrid microcircuit packages, all appropriately marked with a code number.

Task 3. This task consisted of fabricating four identical sets of field test packages. Each set included ten sealed hybrid microcircuit packages, all appropriately marked with a code number. Some packages were seeded and others were empty. The empty packages were intended to serve as "dummy" packages designed to fool the PIND test. A dummy package would represent a "good" hybrid and should not be rejected by a PIND tester.

Task 4. This task covers the documentation for the program. Included were two bimonthly letter-type progress reports, a final report, and a standard test device preparation specification which is included as Appendix B of this Final Report.

3.0 TASK 1. PREPARE AND CHARACTERIZE PARTICLES

3.1 METHODS FOR MANUFACTURING PARTICLES

Task 1 of this program included an investigation of novel particle manufacturing techniques. Recent texts on powder metallurgy⁽⁴⁾, ⁽⁵⁾ disclosed the following methods of powder manufacture. These methods produce a variety of different types, shapes, and sizes of powders.

- (1) Atomization of liquid (molten) metals by forcing liquid metal through a small orifice and then bombarding the emerging melt with a stream of compressed gas or liquid. This method is also called spraying.
- (2) Mechanical processing of solid materials using ball mills, eddy mills, machining, crushing, graining, etc.
- (3) Shotting. This method involves pouring molten metal into air or a neutral atmosphere. It may be forced through screens or orifices into water which acts as a quench bath. A shot tower or a liquid disintegrator may be used.
- (4) Condensation
- (5) Thermal decomposition
- (6) Reduction
- (7) Precipitation and replacement
- (8) Carburization and decarburization
- (9) Electrodeposition
- (10) Electrical dispersion
- (11) Diffusion alloying
- (12) Alloy disintegration

In addition to the above methods, other novel particle manufacturing techniques were made known to this investigator through conversations with particle manufacturers, through laboratory experiments, and through discussions with powder metallurgists and others who have developed ingenious methods to fulfill an immediate need. These other techniques are included in the following listing. They were selected primarily because of their potential for producing spheres which are 0.025 mm (1-mil) diameter or larger.

- (1) Spherical particles of low melting metals and alloys can be produced by squirting or forcing (by pressure) molten metal through a hypodermic needle, capillary, or crucible bottom into a bath of silicone oil or other cooling liquid (such as water), or into an oil-filled tower several feet high. This is a common technique used by particle manufacturers.
- (2) Flame treatment of airborne powders. This technique involves dropping powder through a hydrogen flame or through the tail flame of a plasma torch. It instantly melts, solidifies, and drops into a distilled water bath.
- (3) Cut fine wires into predetermined lengths to get a known volume, then drop the wire segments into a molten salt bath. This is another common technique used commercially.
- (4) Use a mold to cold head certain metals, such as lead.
- (5) Shaking solder from the end of a hot soldering iron tip onto a colder non-wetting surface or into a water bath where it will ball up.
- (6) Screen thick film gold paste onto a ceramic or quartz plate, then heat it to 1600°C. The paste will form small gold balls.
- (7) Use the hydrogen flame-off of a thermocompression bonder to form balls on the end of 0.025 mm (1-mil) or .050 mm (2-mil) diameter gold wire. The balls are then cut off and used as particles.

- (8) Flame spraying into a long room. Three types of flame spraying guns which are suitable for this method are made by Metco, Inc.: (1) a Metallizing Gun; (2) a Thermo Spray Powder Gun, and; (3) a Plasma Flame Spray Gun. The latter type of gun utilizes an electric arc contained within a water-cooled jacket. An inert gas passes through the arc and is excited to very high temperatures. Powder particles are introduced into this thermal plasma, melted, and then projected from a nozzle.
- (9) Miscellaneous methods. These include exploding wires, fluidized bed techniques, and embedment lapping. This last method (i.e., embedment lapping) differs from all the other novel methods in that it is a method for producing small precision rods, rather than spheres. A series of straight wire lengths are encapsulated together to form a bundle of parallel wires. These are then cut and lapped to precise predetermined lengths. When the encapsulating wax is dissolved, the small rods are retrieved.

For this program, it was found to be more advantageous economically and practically to use commercially-manufactured particles. These are discussed in the following section of this Final Report.

3.2 PROCUREMENT OF COMMERCIALY-MANUFACTURED PARTICLES

The following nine vendors were contacted as possible sources for purchasing small calibrated spherical particles of gold, solder, aluminum, lead, iron, nickel, tungsten, or tantalum. Tungsten and tantalum were candidates because of their high densities, not because of their usage in hybrids.

- Fansteel, Inc.
- The Pesses Co.
- Alpha Metals
- Handy and Harman
- Western Gold and Platinum Co.



- Allied Chemical
- Indium Corp. of America
- Semi-Alloys, Inc.
- Clad Metal Industries, Inc.

Only four of these vendors had the capability of supplying any of these materials in diameters from 0.013 - 0.178 mm (0.0005 - 0.0070-inch). Indium Corporation and Alpha Metals would only supply solder and lead balls. Semi-Alloys and Clad Metal could supply several types of material in spherical form. The materials were finally narrowed down to solder, gold, aluminum, and lead. Gold and solder are the particle materials most frequently found as contaminants in hybrid microcircuits at Hughes. Finally, upon mutual agreement between Hughes and NASA, gold was selected as the single material to be used throughout this program. Clad Metal Industries, 325 Midland Avenue, Saddlebrook, N. J., 07662 was the vendor selected for these gold balls.

Three sizes of gold balls were ordered:

- 0.0254 mm (0.001 inch) diameter, \pm 0.0025 mm (0.0001 inch)
- 0.0356 mm (0.0014 inch) diameter, - 0.0025 mm (0.0001 inch) + 0.005 mm (0.0002 inch).
- 0.0457 mm (0.0018 inch) diameter, \pm 0.0025 mm (0.0001 inch).

Clad Metals reported that these particles were made from 99.99 percent pure gold flake powder by dropping the powder into a special salt mixture heated to a temperature above the gold melting point. The surface tension of the salt bath causes the gold powder to melt and form a spherical shape. After the salts have cooled, the gold balls are removed and sized using appropriate sieves with opening tolerances of \pm 2 microns. The vendor also reports that spectrographic analyses have shown that the salt bath does not contaminate the gold.

3.3 METHODS FOR CHARACTERIZING PARTICLES

Part of Task 1 of this program involved accurately characterizing the mass of the particles to be used - all of which will weigh 1 microgram or less and will be less than 0.05 mm (2-mil) in diameter. For this reason, various ways of characterizing small particles were initially investigated.

Common methods for characterizing small particles, as reported in various texts^{1, 2, 3, 4} include:

1. Sieve analysis. This is perhaps the easiest and most rapid method. It classifies particles according to geometric similarity, regardless of density, by using a series of sieves having different size openings. The sieving may be done wet or dry and the sieves are commonly of woven wire mesh or electroformed micromesh.
2. Microscopy. This is an accurate but very expensive method. It includes optical microscopy and electron microscopy. A part of this technique may involve taking photomicrographs of the particles.
3. Sedimentation and elutriation. These methods are used for sub-sieve particle ranges and are applicable for a relatively broad range of sizes. Both compare particles on the basis of similar velocities of particles settling in some liquid or gas. Sedimentation may be gravitational or centrifugal.
4. Surface area measurements. These include techniques such as permeability, adsorption from gases, and adsorption from a solution.
5. Particle trajectory. This method involves the fact that the path described by a particle in a fluid stream is related to its mass and velocity.

6. Optical light scattering or transmission. This method (also called turbidimetry) involves the properties of a beam of light as it passes through a stable suspension particles in a liquid. The same principle has been applied to radiation scattering using x-rays.

7. Miscellaneous. This category include methods such as electrostatic precipitation, electrical sensing zone method (Coulter Principle), diffusion, and sonic analysis.

Hirschham⁴ has published a table listing the useful size range of some of the sizing methods. His table is reproduced below as Table 1.

Table 1. Common Methods of Particle Size Determination

Class	Method	Approximate Useful Size Range (microns)	
Sieving	Seiving using mechanical agitation or ultrasonic induced agitation and screens	44	-800
Microscopy	Micromesh screens	5	- 50
	Visible light	0.2	-100
	Electron microscopy	0.001	- 5
Sedimentation	Gravitational	1	-250
	Centrifugal	0.05	- 60
Turbidimetry	Turbidimetry (light intensity attenuation measurement)	0.05	-500
Elutriation	Elutriation	5	- 50
Electrolytic Resistivity	Coulter counter	0.5	-800
Permeability	Fisher sub-sieve sizer	0.2	- 50
Surface area	Adsorption from gas phase	0.01	- 20
	Adsorption from liquid phase	0.02	- 50

Although not mentioned in the referenced texts, another obvious method of determining the mass of particles is to weigh them. This is called the gravimetric method and it involves weighing of individual particles on special analytical balances (such as electrobalances). Unfortunately commercial balances sold by companies such as Mettler, Cahn, or Perkin Elmer are not sensitive enough to weigh individual particles of the

small masses in which we are interested. For some balances it is claimed that they have sensitivities of ± 0.1 microgram and will read to 1 microgram under specially-controlled weighing conditions. However, their accuracy is doubtful in these ranges. To accurately weigh small spheres weighing in the order of 1 microgram would probably require a specially constructed quartz fiber torsion balance.⁶ Weighing would have to be done in a special room under a special atmosphere. The expense of such a microbalance is not within the means of this program. Balances could be used to weigh hundreds of particles at once and then calculate an average weight per particle, but this method would not be suitable for this particular program which demands knowledge of the exact mass of each individual gold ball prior to placing it into the hybrid package.

3.4 SELECTION OF PARTICLE WEIGHTS AND SIZES

Three different particle masses were selected for seeding the standard test packages and the field test packages. The selection criteria used was:

- One particle size should be reasonably easy to detect by PIND testing and thus its mass should be above the PIND test detectability threshold level.
- One particle size should be as nearly as possible at the threshold level. This would establish a baseline for adequate PIND test equipment.
- One particle size should be difficult to detect for the average PIND test equipment, thus its mass would be below the threshold level. However, too small a particle would be difficult to handle, impossible to detect, and would be unrealistic since it is unlikely that it would ever cause a failure.

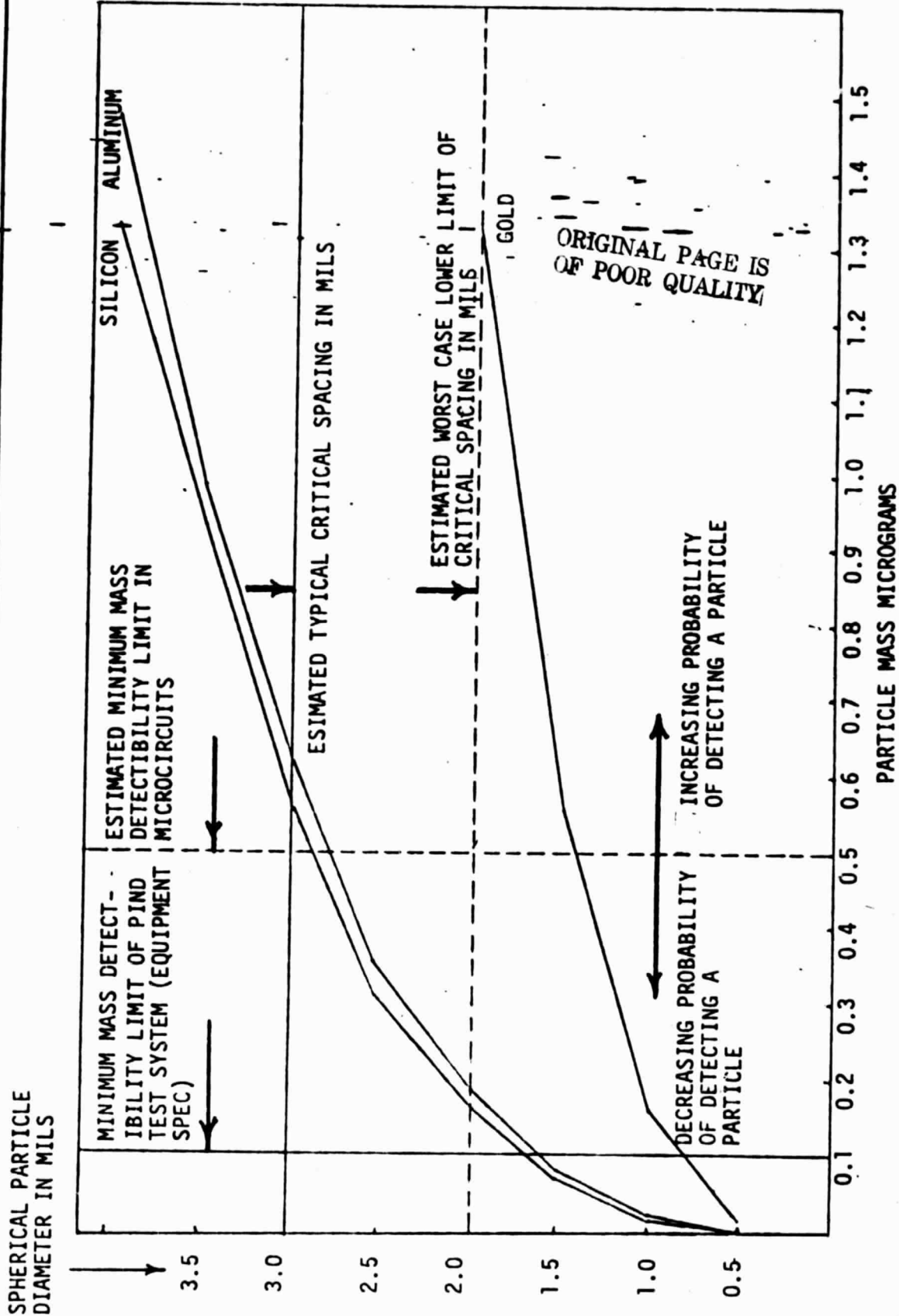
The threshold limit was determined from a study and chart prepared by Mr. S. Gaudiano, NASA/Johnson Space Center. This chart is reproduced as Figure 1. Using this chart, the threshold level is a particle mass of 0.5 micrograms. The "above-threshold" level was selected as 1.0 micrograms and the "below-threshold" level was selected as between 0.1 and 0.2 micrograms.

FIG. 1 DETECTIBILITY THRESHOLD CONSIDERATIONS OF
THE PIND TEST SYSTEM

NASA

Experiment Systems Division-ED
Lyndon B. Johnson Space Center

S. GAUDIANO



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Gold spheres were selected for the particle material and shape. A previous NASA study ⁽⁷⁾ shows this particular type of particle to be an excellent and realistic candidate as a standard for seeding hybrid packages. A ball was selected over other particle shapes because of its availability, repeatability, ease of manufacturing, and because balls of different materials are common hybrid contaminants. There was a certain amount of risk involved in selecting particle masses of 1 microgram or less in that particles this small have a tendency to "hang up" or become entrapped inside hybrid packages either before or during PIND testing and thus are not always detectible by conventional PIND test vibrating. However, to be assured that a particle would never become entrapped would mean selecting particle masses of at least 20 micrograms. A gold ball this heavy would be 0.03 cm (0.005 inch) diameter. It is felt that the use of particles this large would not be a true test of the capability of the PIND test equipment.

The sizes of the gold balls finally selected were:

- Above threshold, 0.0457 mm (0.0018 inch) diam., 1.0 microgram.
- Threshold, 0.0356 mm (0.0014 inch) diam., 0.5 microgram.
- Below threshold, 0.0254 mm (0.001 inch) diam., 0.17 microgram.

3.5 CHARACTERIZATION OF PARTICLES FOR THIS PROGRAM

The particles used for seeding the packages were gold balls in three sizes (1 microgram, 0.5 microgram, and 0.17 microgram) which had been obtained from Clad Metal Industries, Saddlebrook, N. J. These balls were sized by sieving at Clad Metals. However, sieving was not precise enough for this program.

Scanning electron microscope photographs were taken of some random balls of all three sizes as received from the vendor to check on the roundness of the balls and as a double-check on the size measurements. Typical photographs are included here as Figures 2, 3, and 4. It can be seen from these photographs that the roundness is satisfactory, but that the ball sizes as sieved by the vendor are not adequate for package seeding without

a more selective characterization because of the size variations within each group.

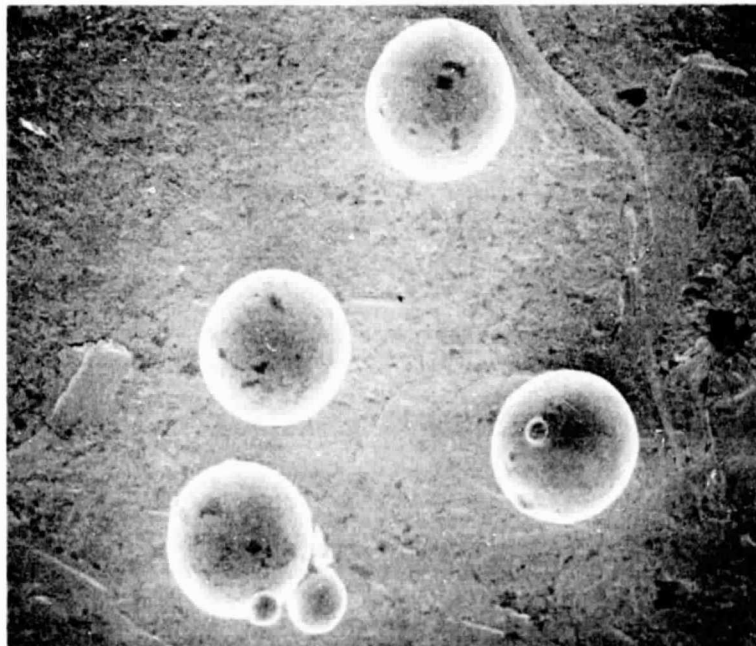
Therefore, prior to package seeding, the balls had to be accurately characterized to ensure that only balls of the proper mass were placed in the designated packages. Characterization was done by optical microscopy methods. The three sizes of balls were characterized by measuring their diameters. Knowing the density of gold and the desired mass of the gold ball (allowing a tolerance of ± 20 percent), the diameter range for each of the three balls was calculated using the expression:

Weight = Density of gold x Volume of sphere

$$\text{Weight} = 318 \text{ grams/in}^3 \times \frac{\pi D^3}{6} (\text{in}^3) \text{ where } D = \text{diameter}$$

$$D^3 (\text{inch}) = W (\text{micrograms}) \times 10^{-6} / 165.36$$

For example, if the desired weight of the ball is 0.5 micrograms ± 20 percent, the diameter range of the gold ball will be 0.034 to 0.039 mm (1.34 to 1.54 mils).



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Figure 2. SEM photograph at 475X of gold balls as sieved to 0.457 mm (1.8 mil) diameter.

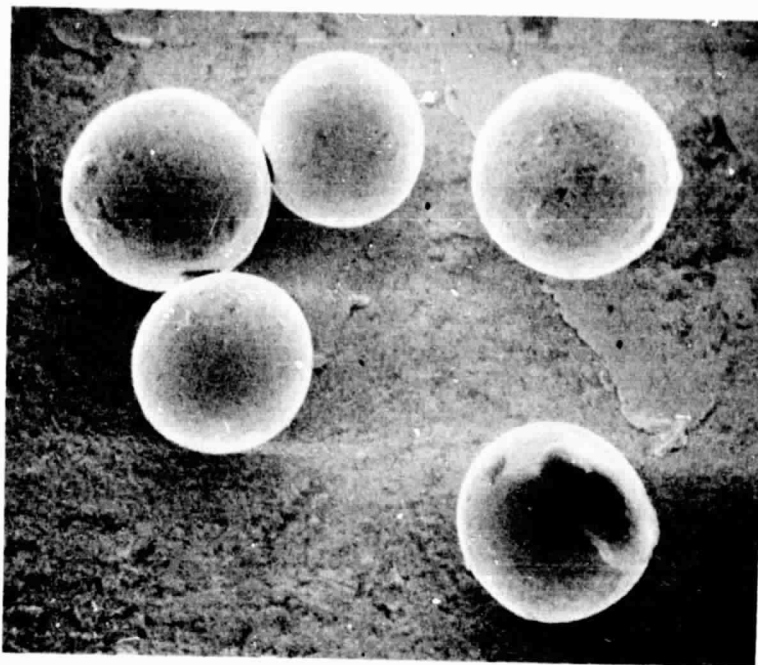


Figure 3. SEM photograph at 679X of gold balls as sieved to 0.0356 mm (1.4 mil) diameter.

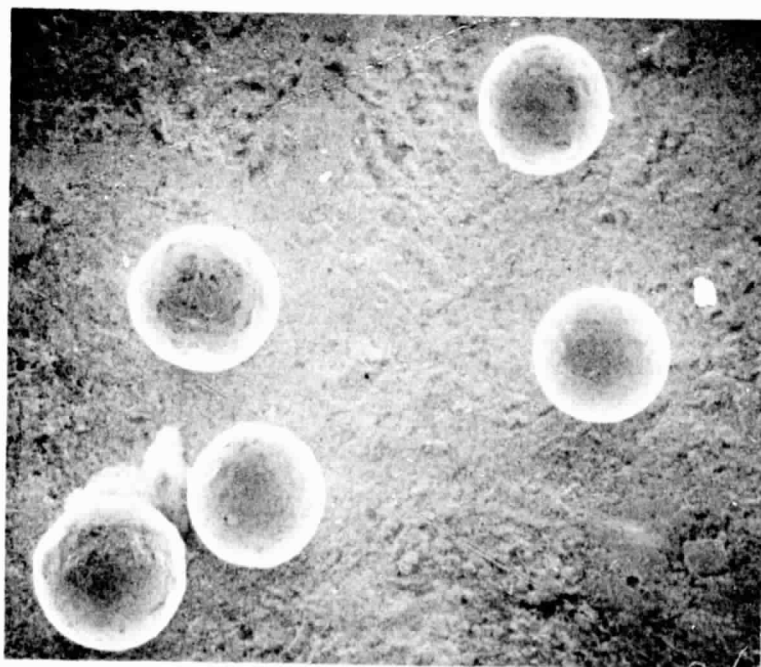


Figure 4. SEM photograph at 624X of gold balls as sieved to 0.0254 mm (1 mil) diameter.

Individual gold balls were placed in small plastic "waffle packs" of the type used to package semiconductor chips. The waffle packs each contained 100 small cavities. By using a B & L Stage Micrometer, a Reichert Metallographic Microscope with a filar eyepiece was calibrated at 500X magnification. The ball diameters were then all measured at 500X with the balls still in the waffle pack cavities. Any ball falling outside the tolerance limits was discarded. A separate waffle pack was used for each of the three gold ball masses desired.

Certain of the field test packages fabricated during Task 3 were seeded with small lengths of gold wire having masses equivalent to gold balls weighing 0.5 to 0.17 micrograms. These rod shaped particles were prepared by using a YAG laser to cut 0.0178 mm (0.7 mil) diameter gold wire into precise lengths.

The correct wire length was determined using the formula:

Weight = Density of gold x Volume of rod

$$= 318 \text{ grams/in}^2 \times \frac{\pi}{4} D^2 \times L$$

where D = wire diameter

L = wire length

$$L (\text{inch}) = W (\text{micrograms}) / 122.43$$

For example, the wire length equivalent to a mass of 0.5 micrograms \pm 20 percent would fall between 0.124 mm (4.9 mil) and 0.081 mm (3.2 mil).

As with the gold balls, the gold rods were accurately characterized by measuring their lengths at 500X magnification.

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4.0 TASK 2. FABRICATE STANDARD TEST DEVICES

4.1 PACKAGE SELECTION

The five different packages selected for this program are listed in Table 2 together with the sealing method which was used. These sizes are representative of the majority of NASA hybrid packages currently being used. Each package eventually had a 0.635 cm (0.025 inch) thick ceramic substrate adhesively bonded to the package base to more-closely simulate the conditions of an actual hybrid.

Figure 5 is a photograph showing inside views of two typical hybrid micro-circuit packages used in this program.

4.2 PACKAGE SEEDING PLAN FOR TASK 2

This plan calls for twenty-five sets of five each seeded packages. A single set consisted of the following five packages:

- One 1 1/4 x 1 1/4 metal butterfly package.
- One 1 x 1 metal butterfly package.
- One 1 x 1 ceramic flatpack.
- One 5/8 x 5/8 metal butterfly package.
- One T0-8 metal package

Each package was seeded with a single gold ball weighing either 0.17 μ gm, 0.5 μ gm, or 1.0 μ gm.

4.3 METHOD FOR SEEDING PACKAGES

The method used to seed the standard test packages is outlined in detail in Appendix A of this Final Report in the form of a specification for the preparation of the test packages. Figure 6 is a block diagram showing the basic process.

Particle entrapment problems were experienced with approximately half of the T0-8 packages and many of the 1 x 1 and 5/8 x 5/8 metal butterfly packages. Although these packages were seeded, no PIND test response (either audible or visual) could be elicited regardless of the efforts made to free the particles. When no PIND test response could be obtained, the package was rejected and a new package prepared. A percentage of all types of seeded packages behaved in this manner, but usually the particle could eventually be freed by using techniques such as heating, prolonged preshocking, coshocking, and ultrasonics. The particle in each package was verified at least twice prior to stenciling. In order to detect some of the smaller particles (i.e., 0.17 microgram gold balls), it was necessary to use a very sensitive PIND test system having a noise level of only 5 millivolts. The Dunegan system used for most of the program had a noise level of 20 millivolts, which would mask the smaller particle responses.

After stenciling of the packages, and immediately prior to shipment of the packages to NASA, several groups of packages were selected at random and again PIND tested. Approximately one-third of the packages experienced particle entrapment problems. The T0-8 header and the 5/8 x 5/8 metal butterfly package gave the most problems.

4.4 PACKAGE IDENTIFICATION

After seeding and sealing the twenty-five sets of five packages each, the cover of each package was stenciled with a code number. This code number identifies the type of package, the number of the group to which that package belongs, and the size of the gold ball sealed inside the package. The key to the code number is given in Appendix A.

Figure 7 shows the top and bottom view of two complete groups of standard test device packages after the packages have been seeded, sealed, and marked. The identifying alphanumeric code follows the word "TYPE" on the top of the cover.

TABLE 2. Package Types and Sealing Methods

Package Type	Package Size (length x width)		Vendor's Package Identification	Cover Identification	Sealing Method
	(cm)	(inch)			
Metal Butterfly	3.2 x 3.2	1-1/4 x 1-1/4	Tekform #50135	Tekform #50409	Parallel seam weld
Metal Butterfly	2.54 x 2.54	1 x 1	Tekform #50260	Tekform #50273	Parallel seam weld
Ceramic Flatpack	2.54 x 2.54	1 x 1	3M Co. #HAC933095-2C	Nardon #933096-2D	Manual soldering
Metal Butterfly	1.59 x 1.59	5/8 x 5/8	Tekform #50181	Tekform #50145	Parallel seam weld
Metal TO-8	1.52 dia.	0.60 dia.	Tekform #80001	Tekform #80006-6	Resistance weld
All of the metal packages and seam welded covers were of Kovar electroplated with gold over nickel. The TO-8 covers were of bare nickel. The soldered covers (Nardon) were of Kovar electroplated with fused tin-over-copper-over-nickel.					

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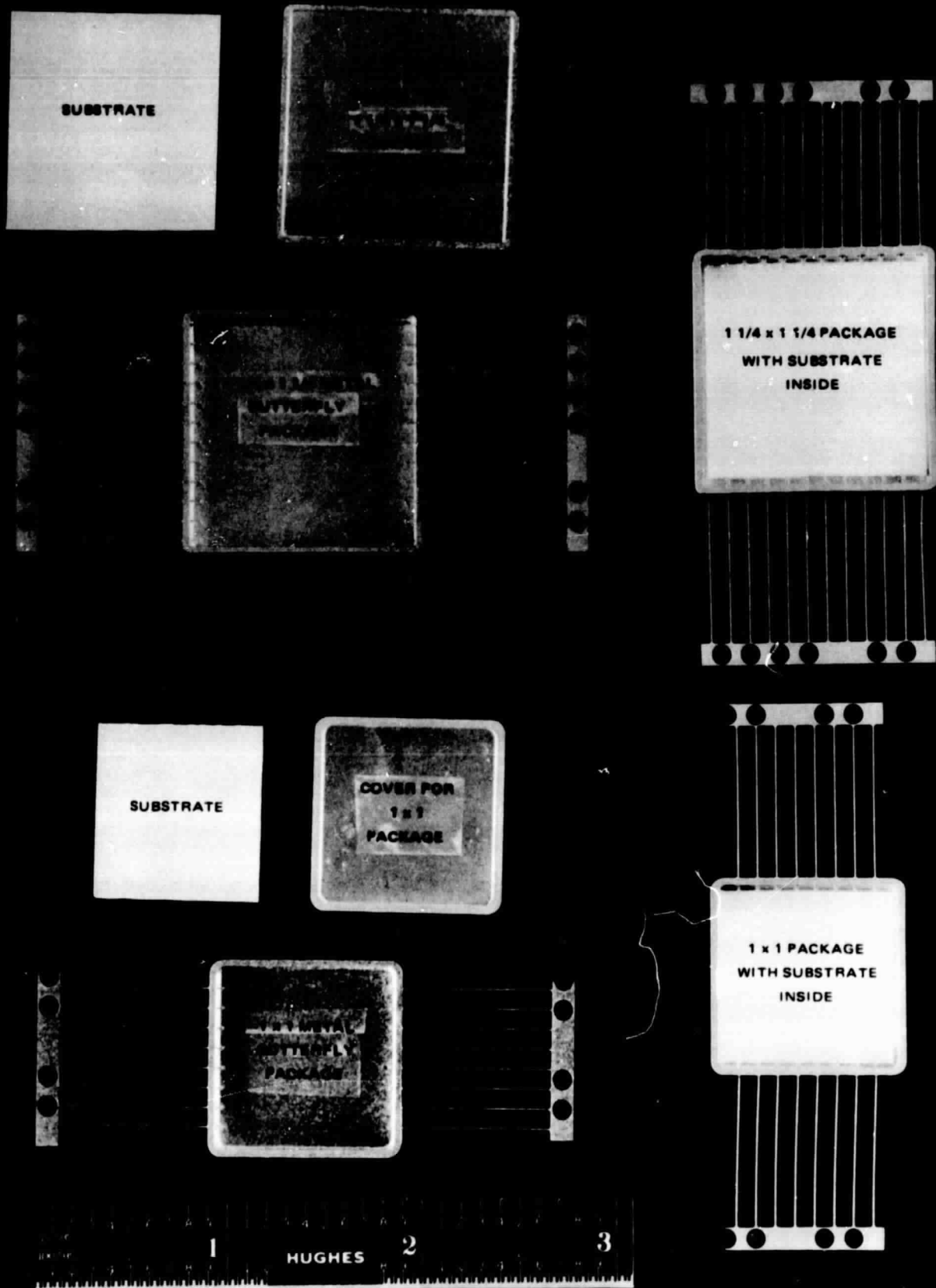


Figure 5. Inside views of two hybrid package types before and after substrate attachment.

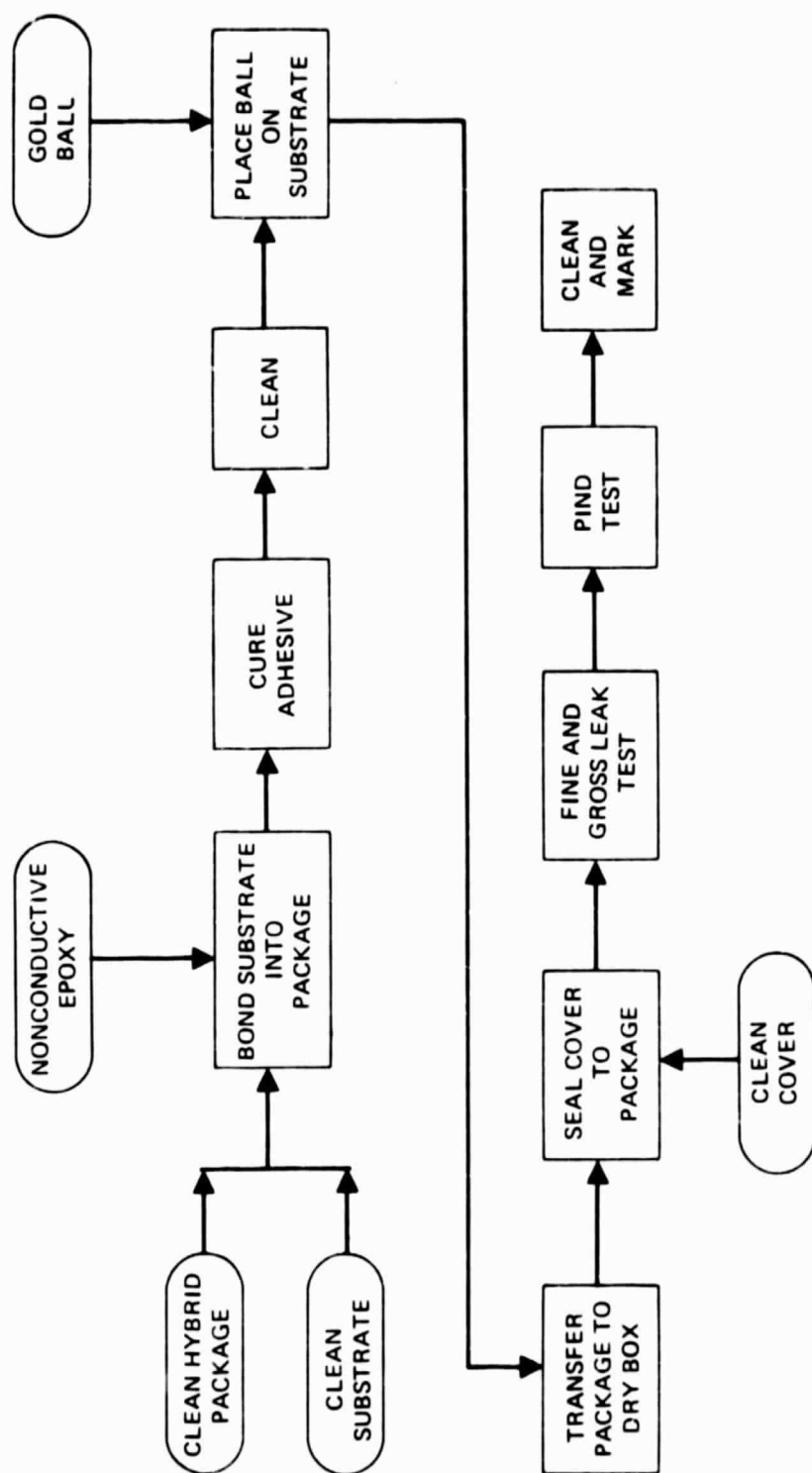


FIGURE 6. BLOCK DIAGRAM OF PROCESS FOR PREPARING STANDARD TEST DEVICES.

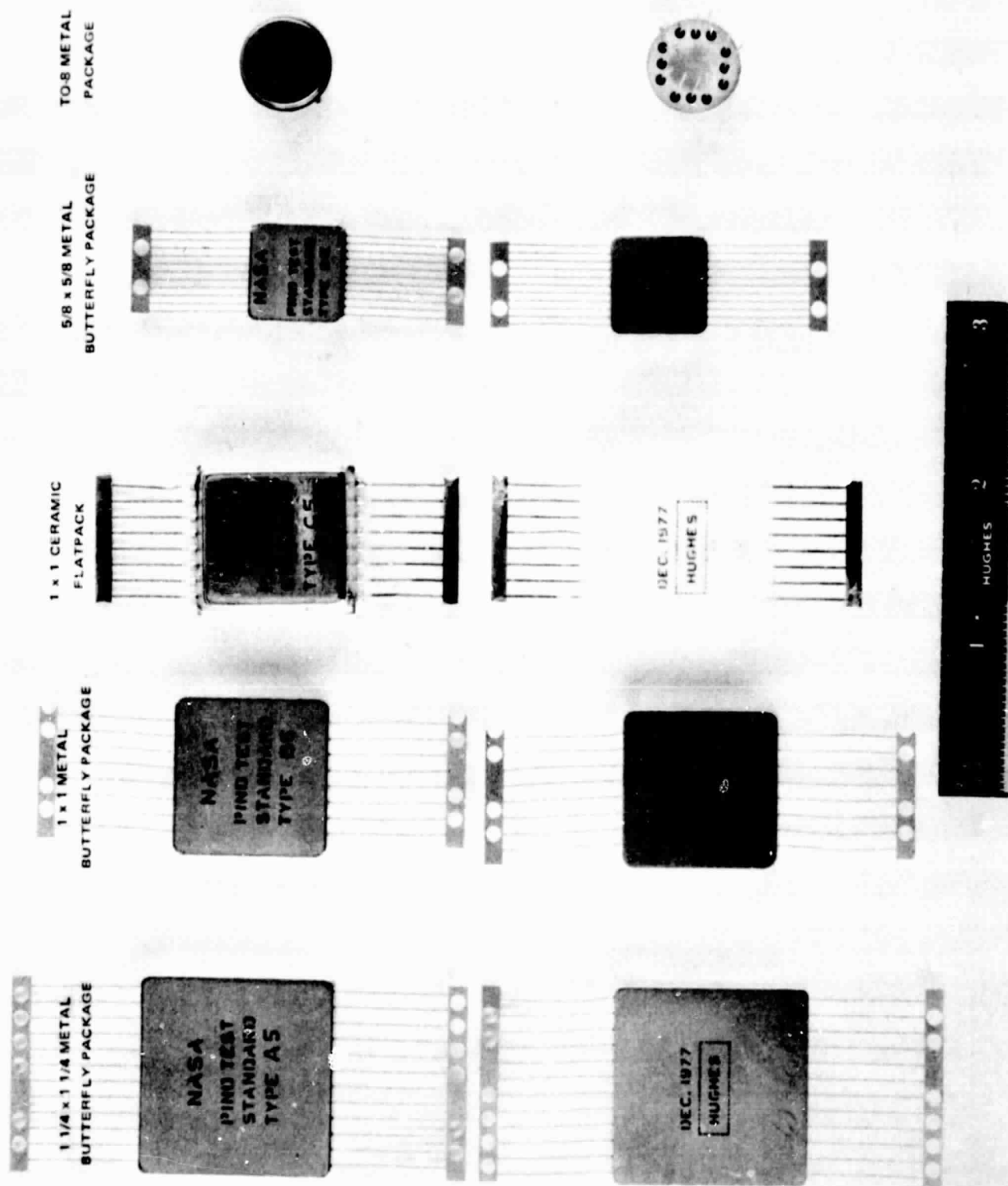


Figure 7. Photograph of the five different package types used in this program after seeding, sealing, and marking. The top view (top row) and bottom view (bottom row) of each package type are shown.

5.0 TASK 3. FABRICATE FIELD TEST PACKAGES

5.1 PACKAGE SEEDING PLAN FOR TASK 3

This plan calls for four sets of ten each hybrid packages. A single set consisted of the following ten packages:

- Two 1-1/4 x 1-1/4 metal butterfly packages.
- Two 1 x 1 metal butterfly packages.
- Two 1 x 1 ceramic flatparks.
- Two 5/8 x 5/8 metal butterfly packages.
- Two T0-6 metal packages.

Some packages were seeded and some were left empty. Different packages were seeded with a different size gold ball. The gold ball weighed either 0.17 μgm , 0.5 μgm , or 1.0 μgm . Others were seeded with a length of gold wire weighing either 0.17 μgm or 0.5 μgm .

5.2 METHOD FOR SEEDING PACKAGES

The method used to seed the field test packages for Task 3 was identical to that used to seed the standard test packages for Task 2. This method was shown in Figure 6 and is detailed in Appendix A.

The only difference in the seeding procedure between the packages for Tasks 2 and 3 is that certain of the packages for Task 3 were not seeded and others were seeded with a small length of gold wire equivalent in weight to a corresponding gold ball. The empty packages (i.e., those not seeded) were intended to act as "dummy" packages. A dummy package would represent a package without a particle and thus should elicit no PIND response.

5.3 PACKAGE CODING

After seeding and sealing the four sets of ten packages each, the cover of each package was stenciled with a code number similarly to those packages in Task 2. The key to the code number is given in Appendix A.



In appearance, the packages in Task 3 were identical to those in Task 2 (see Figure 7), except that each of the package groups in Task 3 contains ten packages instead of five.

6.0 CONCLUSIONS

After a study of various methods for manufacturing small particles, it was determined that the two most economical methods for producing precision spheres in sizes close to 0.025 mm (1-mil) were to: (1) force molten metal through a capillary and have it drop into a cooling bath; and (2) drop powder or fine wire into a molten salt bath. Two vendors (Semi-Alloys and Clad Metal Industries) were found who could supply small calibrated particles. Sieving followed by optical microscopy was found to be a suitable method for characterizing the small gold spheres used in this program.

A procedure for preparing PIND standard test devices was developed and is included as Appendix A in this Final Report. Seeding different hybrid package types ranging in size from 3.2 x 3.2 cm (1-1/4 x 1-1/4 inch) metal butterfly packages to TO-8 headers was found to be possible if reasonable precautions are taken. Small gold spheres could be picked up and transferred to the clean packages on the end of a toothpick wetted with alcohol. Subsequent sealing of the packages is done in dry nitrogen at a dew point of -55°C .

One hundred and sixty-five hybrid packages were seeded and afterwards PIND tested. An alphanumeric code was stenciled on the cover of each package to identify the type and size of the particle with which that package was seeded. With suitably sensitive PIND test equipment and a trained operator, it was found possible to detect even the smallest particles, such as gold spheres weighing only 0.17 microgram. Since particles of this size have a tendency to become quickly entrapped, it was found necessary to use techniques such as preshocking and coshocking to free the particles so they could be detected.

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7.0 ACKNOWLEDGEMENTS

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APPENDIX A

IDENTIFICATION CODE FOR SEEDED PACKAGES

Standard Test Packages in Task 2

	Group 1	Alphanumeric Group	Group 25
	A1	Group 2	A25
1-1/4 x 1-1/4 metal butterfly package seeded with a 1 μ m gold ball.		A2	A25
1 x 1 metal butterfly package seeded with a 0.5 μ m gold ball.	B1	B2	B25
1 x 1 ceramic flatpack seeded with a 0.5 μ m gold ball.	C1	C2	C25
5/8 x 5/8 metal butterfly package seeded with a 0.17 μ m	D1	D2	D25
T0-8 metal package seeded with a 0.17 μ m gold ball.	E1	E2	E25

Field Test Packages in Task 3

	Group 1	Alphanumeric Code	Group 3	Group 4
	F1	Group 2	F3	F4
1-1/4 x 1-1/4 metal butterfly package seeded with a 1 μ m gold ball.		F2	F3	F4
1-1/4 x 1-1/4 metal butterfly package (not seeded).	G1	G2	G3	G4
1 x 1 metal butterfly package seeded with a 0.5 μ m gold ball.	H1	H2	H3	H4
1 x 1 metal butterfly package seeded with a 0.5 μ m length of gold wire.	J1	J2	J3	J4
1 x 1 ceramic flatpack seeded with a 0.5 μ m gold ball.	K1	K2	K3	K4
1 x 1 ceramic flatpack (not seeded).	L1	L2	L3	L4
5/8 x 5/8 metal butterfly package seeded with a 0.17 μ m gold ball.	M1	M2	M3	M4
5/8 x 5/8 metal butterfly package seeded with a 0.17 μ m length of gold wire.	N1	N2	N3	N4
T0-8 metal package seeded with a 0.17 μ m length of gold wire.	P1	P2	P3	P4
T0-8 metal package (not seeded).	Q1	Q2	Q3	Q4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROCESS FOR PREPARING CALIBRATED PIND TEST PACKAGES

1. PURPOSE

- 1.1 This specification covers the processes for fabricating calibrated test packages impact noise detection (PIND).

2. APPLICABLE DOCUMENTS

- 2.1 The following document of the latest issue in effect forms a part of this specification to the extent specified herein:

MIL-STD-883 Test Methods and Procedures for Microelectronics

3. EQUIPMENT

- 3.1 Binocular microscope, variable magnification, 7X to 30X capability.
- 3.2 Weller W-TCP soldering iron.
- 3.3 Solid State Equipment Corp. Seam Sealer mounted in a dry box.
- 3.4 Raytheon resistance welder consisting of a Model 788 weldpower head and a Model 1100 power supply mounted in a dry box.
- 3.5 NRC Model 925 mass spectrometer helium leak detector capable of meeting the requirements of MIL-STD-883, Method 1014.
- 3.6 Trio-Tech gross leak tester capable of meeting the requirements of MIL-STD-883, Method 1014.
- 3.7 Oven, circulating air, capable of +150°C operation.
- 3.8 Sharpened metal toothpick or needle.
- 3.9 Pin holder, Starret, or equivalent.
- 3.10 Dunegan/Endevco PIND equipment, or the equivalent, capable of vibrating hybrid packages at a minimum of 40 - 60 Hz and 8 - 10 G.
- 3.11 Baron-Blakeslee Model MLR-120 vapor degreaser, or the equivalent.
- 3.12 Spray gun, Binks Model Wren B, or equivalent.

4. MATERIAL

- 4.1 Alcohol, methyl, electronic grade
- 4.2 Nonconductive epoxy adhesive, Scotchcast 281
- 4.3 Sn96 solid core wire solder

- 4.4 Freon T.F.
- 4.5 Trichloroethylene, electronic grade
- 4.6 Paint, epoxy, black, Warnow ink M-O-N W/A, Warnow Process Paint Co.
- 4.7 Ink thinner, Warnow TP 1001
- 4.8 Gold spheres of the proper weight, Clad Metal Industries, Saddlebrook, N. J., or the equivalent
- 4.9 Ceramic or metal hybrid packages (with covers and preforms where required) of the platform, flatpack, T0-header, or butterfly configuration.

5. PROCEDURE

- 5.1 Tin the sealing periphery of the 1 x 1-inch ceramic package which is to be solder sealed with Sn96 solder using a soldering iron. The remainder of the package types are sealed by welding and do not need tinning.
- 5.2 Clean all packages and ceramic substrates by a trichloroethylene degrease, hot Freon T.F. spray, Freon T.F. vapor degrease, and a nitrogen blow-off to dry the parts.
- 5.3 Bond an alumina substrate, 0.635 mm (0.025 inch) thick, to the bottom of each package using Scotchcast 281 nonconductive epoxy. Cure for 2 hours at +125°C.
- 5.4 Clean all packages and covers by a methyl alcohol rinse followed by a Freon T.F. spray and degreasing. Blow dry with nitrogen.
- 5.5 Pick up a gold ball of the proper mass from the waffle pack by using a sharpened toothpick dipped in methyl alcohol. The ball will cling to the alcohol drop. This operation must be done under a microscope because of the small size of the balls.
- 5.6 Carefully transfer the ball to the middle of the substrate on the bottom of the package. Where T0-8 packages are used, the ball is placed in the middle of the inverted nickel cap, since sealing is done in the lid-down position.
- 5.7 Place the packages and covers in the sealer dry box. The dry box should be filled with dry nitrogen and have a dew point of at least -55°C prior to sealing.

5.8 Align the cover on the package and seal. The 1 x 1-inch ceramic flatpacks are solder sealed using a soldering iron and Sn 96 solder (i.e., 96 percent tin/4 percent silver) without flux. The T0-8 headers are resistance welded. The three sizes of metal butterfly packages are parallel seam welded using a SSEC Seam Sealer. Although the above described equipment was used to seal the packages for this particular program, other hermetic sealing methods would be just as applicable. Regardless of the method used, care must be taken so that the ball doesn't escape from the package prior to or during sealing and that the sealing operation does not introduce unwanted particles into the package.

5.9 Fine and gross leak each package per MIL-STD-883, Method 1014.

5.10 PIND test each package to make sure that the particle with which the package was seeded is still inside and free to rattle around. PIND testing should be done per MIL-STD 883B, Method 2020. Small particles weighing less than 10 micrograms have a tendency to "hang up" or become entrapped within the package. However, with persistent preshocking or coshocking, the majority of particles will eventually come loose and give a PIND test response.

5.11 Mark each package cover by spraying the appropriate identification through a brass stencil using a black epoxy ink. Bake ink for 10 minutes at +125°C.

6. REQUIREMENTS

6.1 The seeded hybrid package shall contain only the particle with which it was seeded. Evidence of other unwanted particles within the sealed package shall be cause for rejection.

6.2 The seeded hybrid package must be hermetic.

6.3 The seeded hybrid package shall be capable of eliciting an audible and visual PIND response from a properly-tuned PIND test equipment.